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PUBLICATION NOTES

Production of *California Fish and Game* is still behind schedule. Worse yet, the amount of foreign correspondence coming in has led us to the obvious conclusion that none of our foreign subscribers received Volume 78(2). We have since re-issued the publication to all foreign subscribers and extend our apologies for the mix-up.- *Eric R. Loft*

CALIFORNIA FISH AND GAME
Calif. Fish and Game 78(4):136-144

MOLT FREQUENCY AND SIZE-CLASS DISTRIBUTION IN THE CALIFORNIA SPINY LOBSTER (*PANULIRUS INTERRUPTUS*) AS INDICATED BY BEACH-CAST CARAPACES AT SAN NICOLAS ISLAND, CALIFORNIA

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Adult California spiny lobster (*Panulirus interruptus*) are described as molting once or more than once annually. We measured 815 beach-cast spiny lobster carapaces found along a 1.3-km section of San Nicolas Island, California, in 1988 and 1989. Of these, 759 (93%) were found during the months of August, September, and October, suggesting a single annual molt for adult animals. The average size of a beach-cast carapace was 79 mm carapace length (CL), compared with an average size of 92.1 mm CL for 1000 animals captured live in the same area.

INTRODUCTION

Growth in the Palinuridae occurs at ecdysis (Aiken 1980). The rate of growth is dependent on the molt frequency and the change in size per molt or growth increment. Previous methods to define molt frequency in spiny lobsters include observed changes in carapace condition over time (Mitchell et al. 1969), observations of molting in captive animals (Lindberg 1955, Chittleborough 1976, Nair et al. 1981), and changes in carapace lengths of marked and recaptured animals in the wild (McKoy 1985, Hunt and Lyons 1986). Estimates of the growth increment in spiny lobsters have generally been obtained from analyses of size distributions of captured animals (Mitchell et al. 1969, Chittleborough 1976) or observed changes in carapace lengths (CL) of marked individuals in the wild (Chittleborough 1976, Newman and Pollock 1974, McKoy 1985, Annala and Bycroft 1985, Ebert and Ford 1986) or captive animals (Lindberg 1955, Chittleborough 1976, Nair et al. 1981). Although considerable variation exists in documented molt-frequency in the Palinuridae (Aiken 1980), palinurid lobsters are recognized as following a common trend in decapod crustaceans of decreasing molt frequency with increasing age (Aiken 1980).

The California spiny lobster (*Panulirus interruptus*, Randall), occurs from Magdalena Bay, Baja California Sur, Mexico, northward to Point Conception, California (Shaw 1986, Holthuis 1991), and small isolated populations are reported

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as far north as the Monterey Peninsula, California (Schmitt 1921). Effective management of this recreational and commercially exploited resource requires accurate information on basic life history parameters (e.g., growth rates). Molt frequency for adult California spiny lobsters has been described as occurring once (Backus 1960, Mitchell et al. 1969) and twice annually (Lindberg 1955). These differences in molt frequency led to estimates of age at recruitment into the California fishery (83 mm CL) from 7 (Lindberg 1955) to 11 years (Mitchell et al. 1969).

The purpose of this study was to describe the temporal pattern of molting and the size structure of a population of California spiny lobsters as indicated by beach-cast carapaces along the shoreline of San Nicolas Island, California. The analysis of beach-cast carapaces is a new approach to examining growth processes in the California spiny lobster. To evaluate the technique, we compared the size class distributions of beach-cast carapaces with a sample of live lobsters captured offshore.

METHODS

The study area consisted of 1.3 km of shoreline along the northeast side of San Nicolas Island (Fig. 1). This section of shoreline was selected after several years of observations of the seasonal occurrence of lobster carapaces similar to the patterns described herein. Furthermore, offshore from this area were the sites used for the collection of live lobsters (Bodkin and Kenner 1988). From August 1988 through November 1989, we searched the study area at about two-week intervals during low tide. Each lobster carapace was measured dorsally from the anterior margin of the supra orbital groove to the posterior border of the cephalothorax, to the nearest mm in length (CL). Carapaces were crushed following examination to prevent resampling.

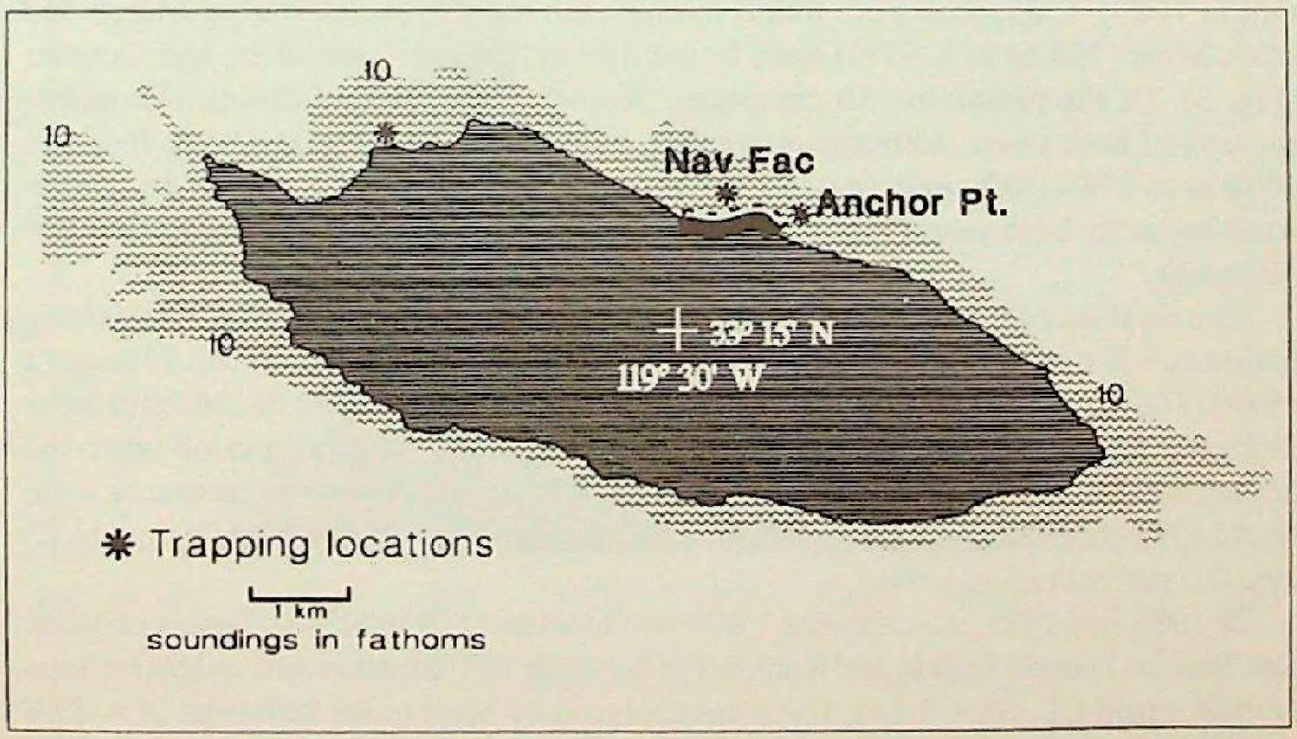

Figure 1. The study area at San Nicolas Island, illustrating coastal segment where carapaces were collected (---), and lobster capture sites (*).

Sex could not usually be determined because the exoskeletons were frequently disarticulated.

In 1988 and 1989, live lobsters were captured around San Nicolas Island either by hand or with traps similar to those used in the commercial fishery, except that no escape ports were provided for sub-legal lobsters. We collected live lobsters by hand, either free-diving or with the aid of SCUBA, during both day and night. Hand caught lobsters were collected from two depth-strata, the intertidal (< 3-m deep) and the subtidal (between 3- and 15-m deep). Lobster traps were set at water depths between 5 and 15 m in areas that contained apparently suitable lobster denning habitat as determined from visual observations while SCUBA diving. Traps were baited with 150-200 g of abalone trim (*Haliotis* sp.) or Pacific mackerel (*Scomber japonicus*). Traps were pulled daily and re-baited. Captured lobsters were sexed, measured (CL), marked and released. The reproductive status of each captured female was qualitatively assessed by the following categories; 1) recently deposited spermatophore present, female had mated; 2) berried, extruded eggs present; or 3) non-reproductive, eggs or recent spermatophore absent.

Comparisons of mean carapace lengths between beach-cast and live-caught lobsters and between live-caught lobsters by method of capture were made with a two-sample *t*-test. A significance level of 0.05 was established *a priori*.

RESULTS

We found and measured 815 beach-cast lobster carapaces during this study. Recovered carapaces ranged in size from 34 to 153 mm CL (Fig. 2), with a mean size of 79 mm. Mean carapace length did not differ between years (79 mm in 1988 and 80 mm in 1989). Carapaces were found during each month, except during March and May. Most (759 of 815, 93%) were found during August, September, and October (Fig. 3). Of the remaining 56 carapaces, 36 (64%) were found during November surveys of both years. Although more than twice as many carapaces were found in 1988 as in 1989 (582 compared to 233), the temporal pattern of carapace deposition was similar for both years (Fig. 3). In both years carapace recovery had ceased by late November.

The smallest carapaces were usually recovered during the early part of the molting period ($\bar{x}$ = 72 mm CL, SE = 1.43, 29 August 1988; $\bar{x}$ = 68 mm CL, SE = 1.82, 13 August 1989). The largest carapaces were found next ($\bar{x}$ = 90 mm CL, SE = 3.58, 26 September 1988; $\bar{x}$ = 88 mm CL, SE = 8.41, 27 August 1989). Following this period when the largest carapaces were recovered was an extended period when most carapaces were found (50% in 1988 and 78% in 1989). These carapaces averaged from 76 mm to 83 mm CL per collection period.

In 1988 and 1989, we captured 1,000 live lobsters (519 male:481 female) around San Nicolas Island (Bodkin and Kenner 1988), while 157 lobsters were caught by traps ($\bar{x}$ = 89.1 mm CL, SE = 1.14), 403 were captured by hand in the intertidal ($\bar{x}$ = 89.8 mm CL, SE = 1.33), and 440 were taken by hand in the subtidal ($\bar{x}$ = 96.1 mm CL, SE = 1.43). The general trend in female reproductive status throughout the year is

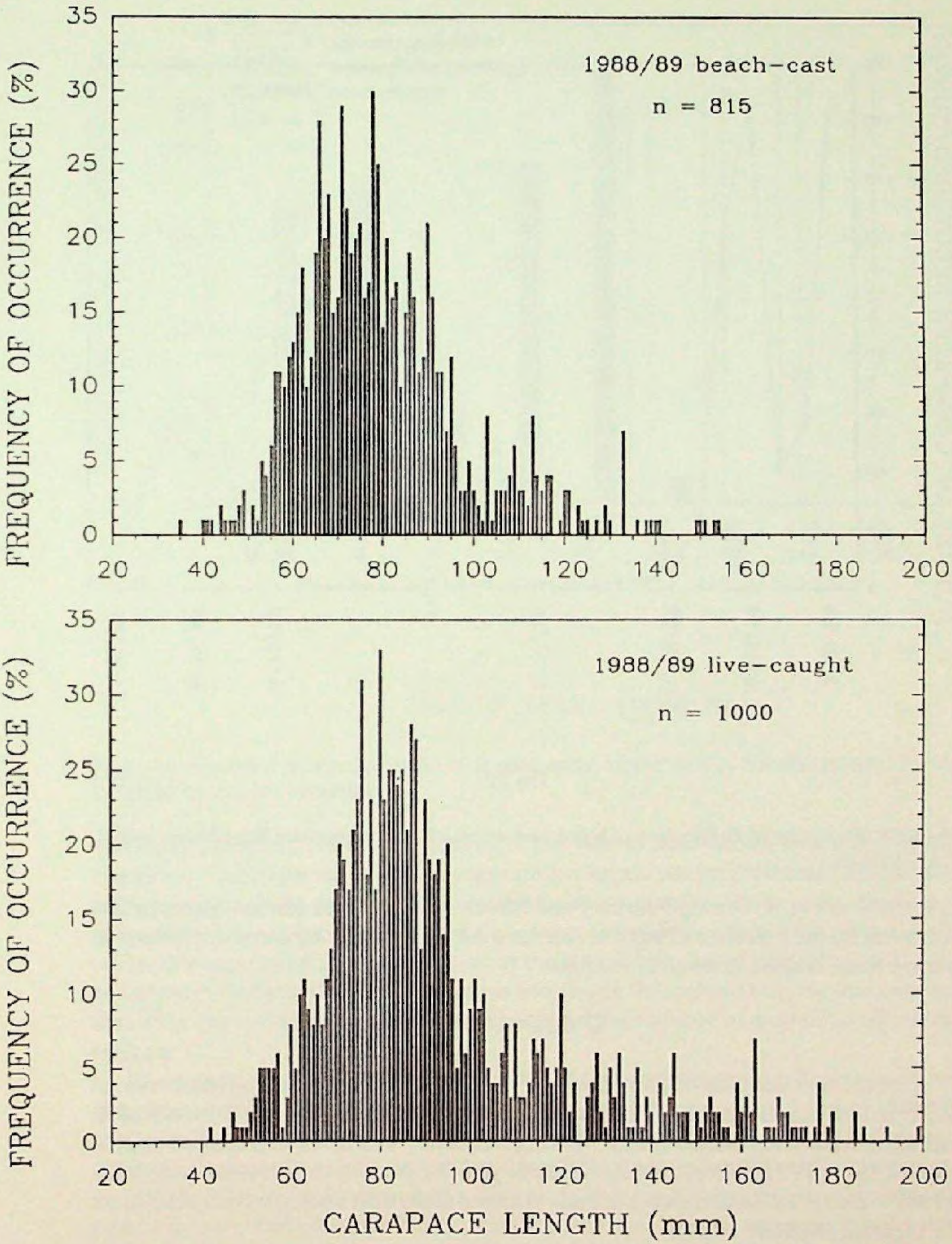

Figure 2. Size-class distribution of 815 beach-cast and 1000 live-caught spiny lobster carapaces at San Nicolas Island, CA, 1988-1989.

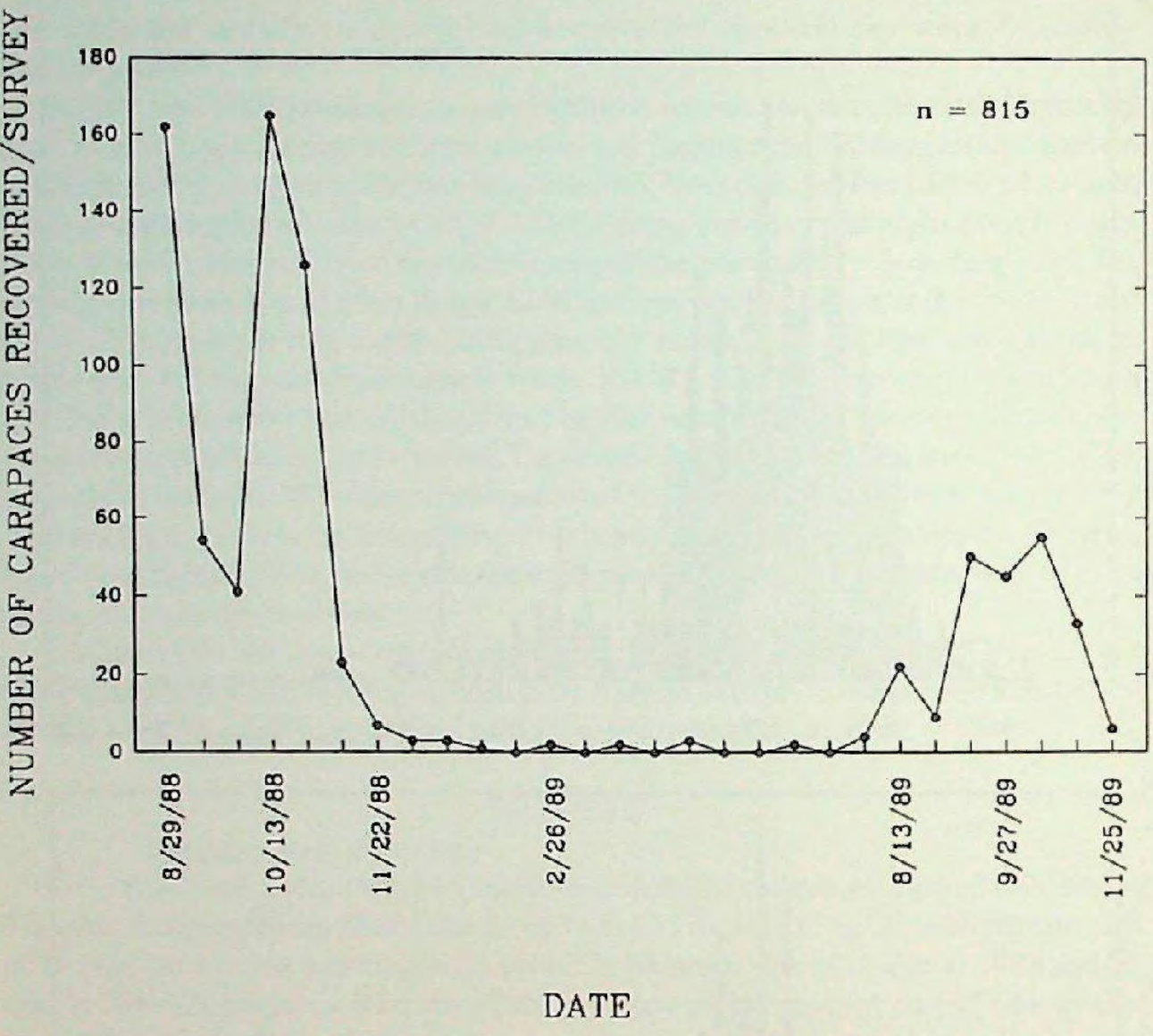

Figure 3. The temporal distribution of beach cast-spiny lobster carapaces at San Nicolas Island, CA, 1988-89.

presented in Fig. 4. During February and March, most females carried sperm packs, followed by the presence of eggs in June and July and finally by a non-reproductive period from August through November.

DISCUSSION

Inconsistent patterns of molt frequency are apparent in the Palinuridae. Annual molting was described for adult *Jasus tristani* (Pollock and Roscoe 1977) and adult female *J. lalandii* (Pollock 1986). Molting frequency was described as semi-annual (Smith 1948, 1951) and more than once per year for large *P. argus* (Hunt and Lyons 1986). Adult *J. edwardsii* molt once per year and more than once per year, dependent on location (McKoy 1985).

Molt frequency for adult California spiny lobsters, is described as occurring once (Backus 1960, Mitchell et al. 1969) and twice annually (Lindberg 1955). Our results suggest that within most size classes of *P. interruptus* carapaces encountered during

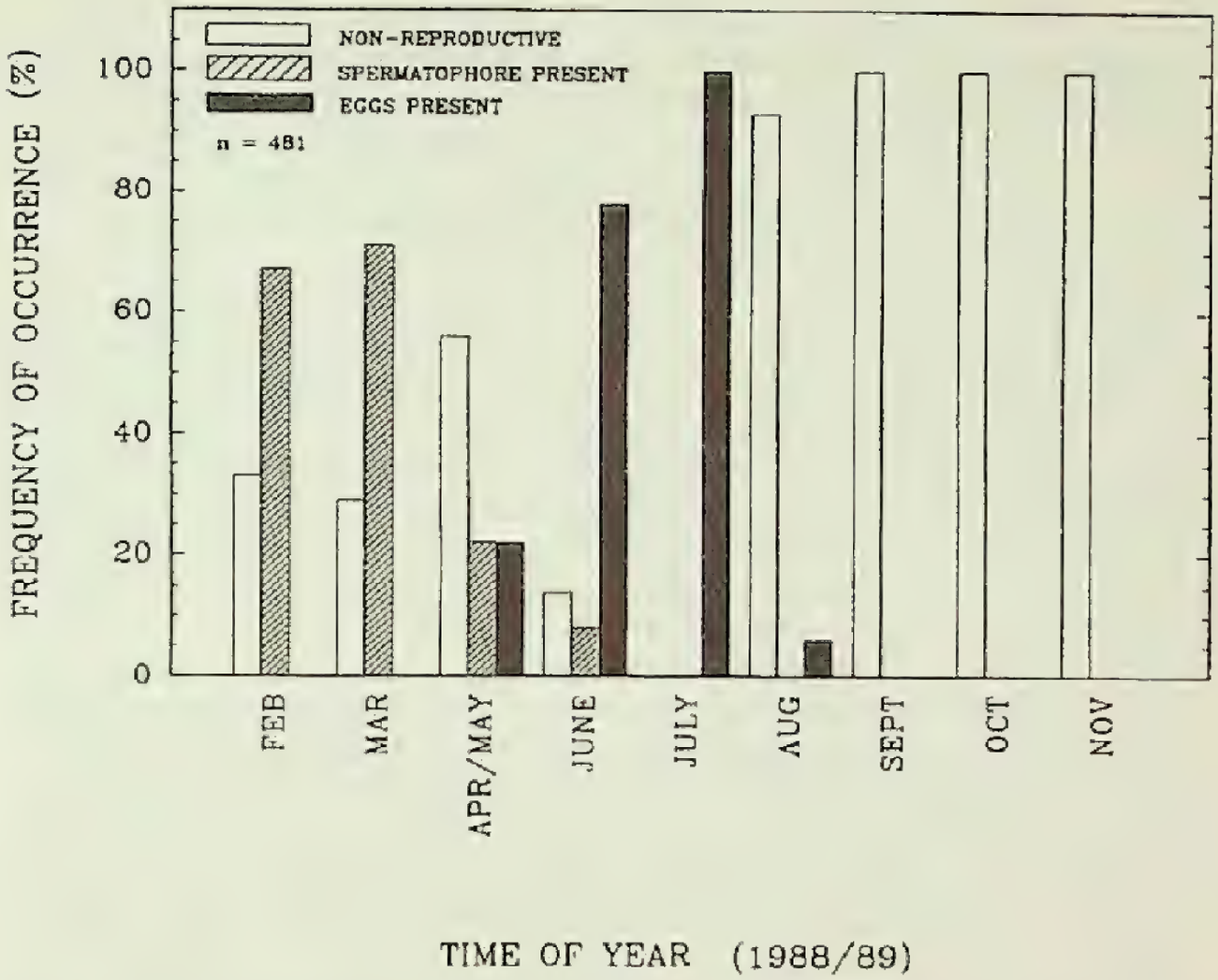

Figure 4. Annual reproductive cycle of female spiny lobster at San Nicolas Island, CA, as indicated by carapace condition.

this study (>50 mm), molting occurs once per year at San Nicolas Island during the months of August through October suggesting a large scale synchronous molt period. Although carapaces were found throughout most months of the year, their low frequency of occurrence may suggest they are not provided as part of the normal molt cycle. We expect that some proportion of the population dies of natural causes, e.g., predation (Lindberg 1955), and becomes beach-cast throughout the year and suggest that at least some of the carapaces we encountered were a result of mortality rather than molting.

Temporal patterns of lobster carapace deposition onshore could reflect the relative abundance of live lobsters offshore. However, observations of live lobsters directly offshore from our study site since 1986 (Bodkin and Kenner 1988) indicate that, although there are fluctuations, lobsters are relatively abundant throughout the year.

Mitchell et al. (1969) described a difference in the initiation and duration of molt period by sex; male lobsters begin to molt about two months prior to females but complete the cycle at about the same time, in late October. Lipcius (1986) described a general pattern in palinurid lobsters in which younger (smaller) lobsters of both sexes molted earlier than older animals. The patterns of carapace deposition we

observed are consistent with these models (Fig. 2).

By analyzing size-class modes, Mitchell et al. (1969) reported growth increments of 3.7 mm CL for males and 4.4 mm CL for females. Lindberg (1955) reported annual growth increments (two molts) of 2 cm in total length (about 6.5 mm CL/year). Engle (1979) reported that juvenile lobsters grow to 56 mm CL in two years. If we use an annual molt after two years (56 mm) and growth increments of 3.2 to 4.4 mm, we estimate age at entry into the fishery of 8-10 years (83 mm).

The mean size of beach-cast lobster carapaces was 79 mm CL, significantly smaller than the mean size of 93.1 mm CL from 843 live lobsters captured by hand around San Nicolas Island ($P < 0.01$) (Fig. 3). Reasons for this difference remain unclear. Within the sample of 843 hand-caught lobsters, we observed a significantly smaller mean size of 90.0 mm CL (SE = 1.26;) for animals captured in nearshore waters less than 3 meters deep, as compared with a mean size of 96.2 mm CL (SE = 1.35;) for animals captured in offshore waters greater than 8 m in depth ($P < 0$ .01). This difference suggests that lobsters may be spatially segregated by size during the molting period and that smaller animals occupy the nearshore in greater relative abundance. However, this difference explains only a small portion of the total difference between the beach-cast and live-caught samples. Additional explanations for this difference may include decreasing the adult molt frequency to less than once per year, after attaining some age or size, or more than one molt per season for smaller animals. Hydrodynamic sorting of nearshore materials may favor the deposition of smaller carapaces on shore, avian and/or terrestrial scavengers may select larger carapaces or live capture methods may be unintentionally biased towards larger animals.

Analysis of the reproductive condition of 481 live female lobsters captured in 1988 and 1989 indicates that reproductive behavior at San Nicolas begins in late winter and ends with the release of eggs late in the summer, followed by a molting period. This reproductive pattern, followed by the occurrence of large numbers of beach-cast carapaces, seems to support the conclusion of Mitchell et al. (1969) that ecdysis in mature California spiny lobsters occurs in late summer and fall after completion of the reproductive cycle.

Our results indicate a prolonged, single, annual molt cycle in California spiny lobsters, extending from August through October at San Nicolas Island. The smaller average size of the beach-cast carapaces compared to the live population offshore suggests lobsters may be segregated by size and depth during the molting period. Furthermore, a decreasing molt frequency in large lobsters may contribute to the observed patterns. Differences in the sizes between beach-cast and hand-captured samples needs further reconciliation before using beach-cast carapaces to describe the size-class structure of the live lobster population.

In conclusion, the presence of beach-cast lobster carapaces seems useful in describing temporal patterns of molting in the California spiny lobster. The U.S. Fish and Wildlife Service (1987) predicted the elimination of commercial and recreational lobster fisheries following the recent re-introduction of sea otters into the nearshore waters around San Nicolas. The methods we describe may be useful for monitoring

change in the size-class distribution and/or as an index to abundance of the lobster population at San Nicolas Island over time. Similar methods may be applied elsewhere, to facilitate the study of the population dynamics of this important crustacean.

ACKNOWLEDGMENTS

This work was supported by the U.S. Fish and Wildlife Service, National Ecology Research Center and Alaska Fish and Wildlife Research Center. Field work on San Nicolas Island was supported by the U.S. Navy, Pacific Missile Test Center. We thank D. Bruden, M. Fedorko, E. Halliday, C. Gramlich, M. Kenner, B. Marinovic, T. Murphey, and C. Robles for their contributions. J. Garth, A. Havens, M. Kenner, C. Robles, E. Rockwell, G. VanBlaricom and two anonymous reviewers provided valuable review of the manuscript.

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CRITICAL THERMAL MAXIMA AND OXYGEN MINIMA OF FIVE FISHES FROM THE UPPER KLAMATH BASIN

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We measured the critical thermal maxima and critical oxygen minima of five fishes from the Upper Klamath basin to determine their relative vulnerability to high temperatures and low dissolved oxygen. Species examined were shortnose sucker (*Chasmistes brevirostris*) speckled dace (*Rhinichthys osculus*) fathead minnow (*Pimephales promelas*) blue chub (*Gila coerulea*) and tui chub (*Gila bicolor*). Three Klamath largescale sucker (*Catostomus snyderi*) were also examined. Species ranked from greatest to lowest thermal maxima as follows: tui chub and fathead minnow similar to shortnose sucker and speckled dace, but greater than blue chub. Shortnose sucker and speckled dace were similar to blue chub. Species ranked from lowest to highest oxygen minima as follows: fathead minnow similar to tui chub and shortnose sucker, but greater than speckled dace and blue chub. Tui chub, shortnose sucker and speckled dace were not significantly different. This information suggests that fathead minnow and tui chub would be most likely to survive, shortnose sucker and speckled dace intermediate, and blue chub least likely to survive high temperature and low dissolved oxygen conditions. Limited information on Klamath largescale sucker suggests they are similar to shortnose sucker and speckled dace. Our observations support the hypothesis that increased temperatures and decreased dissolved oxygen levels have contributed to the decline of fishes in the Upper Klamath basin.

INTRODUCTION

Lost River sucker (*Deltistes luxatus*), shortnose sucker (*Chasmistes brevirostris*), Klamath largescale sucker (*Catostomus snyderi*), and blue chub (*Gila coerulea*) have suffered declines in population numbers in the Upper Klamath basin, Oregon, while tui chub (*Gila bicolor*) and introduced fathead minnow (*Pimephales promelas*) have not.

Blue chubs were once the numerically dominant fish in Upper Klamath Lake (Vincent 1968). Blue chub are no longer dominant (Beinz and Ziller 1987; Jeff Ziller, Oregon Dep. of Fish and Wildlife, unpubl. data) and recent studies suggest blue chub populations are reduced from historic levels, but data necessary to document this decline have not been collected (Jeff Ziller, pers. comm.). Reductions in Lost River and shortnose sucker populations lead to their being listed as endangered (USFWS 1988).

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Mortality of large numbers of Lost River sucker and smaller numbers of shortnose and Klamath largescale sucker and chubs coincided with high water temperatures, low dissolved oxygen levels, and high pH levels during 1986 in Upper Klamath Lake (Scoppettone 1986). Temperatures in Upper Klamath Lake can approach 30°C, dissolved oxygen levels can drop below 4 mg/l, and pH can rise above 10.5 (Coleman et al. 1988). Limnological data suggests these conditions occur more often and last longer today than they did in the past (Coleman et al. 1988). These observations led Scoppettone (1986) and others to hypothesize that poor water quality caused the mortalities.

If deteriorating water conditions were causing reductions in fish populations, then we would expect sucker and blue chub to be less tolerant of these conditions than relatively unaffected species, like tui chub and fathead minnow. Our objective was to measure and compare critical thermal maxima and critical oxygen minima of several fishes from the Upper Klamath basin to predict which would be likely to survive high temperature and/or low dissolved oxygen events.

We looked at temperature and dissolved oxygen tolerances because high temperatures and low dissolved oxygen levels may limit survival and distribution of fish in these systems (Vincent 1968, Scoppettone 1986, Coleman, Kann and Scoppettone 1988, Buettner and Scoppettone 1990). Correlations between tolerance ranges and the range of conditions fish encounter in nature are common (see review in Matthews 1987, Cech et al. 1990), suggesting tolerance is an important determinant of species distribution. We used critical maxima and minima because these methods are an efficient means for comparing the tolerance of fish to environmental stress (Becker and Genoway 1979, Kilgour and McCauley 1986). Matthews and Maness (1979) demonstrated that relative success of four species in thermally stressful environments was directly related to their comparative thermal maxima, suggesting tolerance determines a species' ability to thrive in variable environments.

Species examined in this study were shortnose sucker, speckled dace (*Rhinichthys osculus*) fathead minnow, blue chub, tui chub and Klamath largescale sucker. These species include fishes with declining, stable or increasing populations in the Upper Klamath basin. Only speckled dace inhabit streams their entire life cycle (Moyle 1976). All other species spend significant portions of their lives in lakes (Moyle 1976, Buettner and Scoppetone 1990). We collected no data on Lost River sucker and little data on Klamath largescale sucker because no Lost River sucker and only three Klamath largescale sucker were available.

METHODS

Fishes were collected by seining or electrofishing from the Upper Klamath basin. Shortnose sucker were provided by the Klamath Tribe's Braymill Hatchery. Fish were acclimated to 20°C and fed cladocerans, mosquito larvae, tubificid worms, frozen brine shrimp, and flake food for at least 6 weeks prior to experiments. Several shortnose sucker had incomplete opercular covers and curved spines, possibly indicating an unbalanced diet (lack of vitamin C, Stickney 1979) during early

development. We did not test fish with visible abnormalities.

We followed Becker and Genoway's (1979) guidelines for determination of critical maxima of fishes. Fish were weighed, placed in individual plexiglass tubes (6 cm long, 1.5 cm diameter), acclimatized to the tubes for 2 h, and exposed to increasing temperature (0.3°C per min) or decreasing dissolved oxygen (1.25 torr partial pressure of oxygen [PO_2] per min [1 torr = 133.3 Pa]) to determine their critical thermal maxima and critical dissolved oxygen minima. Five fish were run simultaneously. Care was taken to make sure results for fish run simultaneously were independent (i.e., no visual or chemosensory interaction among fish) and that runs contained fish selected randomly from the six species tested. End-point reported is permanent loss of equilibrium (defined as the temperature or dissolved oxygen level at which a fish could no longer right itself despite prodding with a nylon filament).

Temperature was manipulated by regularly adjusting a mercury thermostat/relay which controlled a pump that mixed hot water (>40°C) with 20° water to achieve the desired temperature (± 0.5°) in a mixing tank. Hot water, 20° water and mixed water were aerated to maintain dissolved oxygen levels at air saturation. Mixed water then flowed through fish enclosures exposing fish to manipulated temperature conditions. Temperature in each enclosure was continuously monitored with temperature probes (YSI Model 401).

Dissolved oxygen concentrations were changed by adjusting an electronic, gas-mixing flowmeter to proportionally mix nitrogen and oxygen. The mixed gas was equilibrated with 20° water in a multi-chambered gas stripping column to achieve the desired dissolved oxygen tension (± 5 torr PO_2). Water from the column flowed through fish enclosures exposing fish to manipulated oxygen levels. Dissolved oxygen tension in the water flowing into the fish enclosures was continuously monitored with an electrometric oxygen analyzer system (Radiometer Model PHM 71/D616/E5046). The plexiglass enclosures denied fish access to the surface where they might respire oxygen-rich water.

Fish weights were compared using ANOVA. Critical minima and maxima values were log-transformed and interspecies differences were compared using a blocked ANOVA with fish weight as a factor. Specific differences were identified using appropriate hypothesis tests (Wilkinson 1988) with sequential Bonferroni adjustments (Rice 1989).

RESULTS

Fish used for each maxima or minima determination were small (between 0.88 g and 3.65 g) and the mean weights for each species were not significantly different (Table 1).

Tui chub and fathead minnow had significantly greater critical thermal maxima than blue chub (Table 2). Shortnose sucker and speckled dace were not significantly different from tui chub and fathead minnow or from blue chub. Datum on one Klamath largescale sucker fell within the ranges for all other species tested.

Fathead minnow had a significantly lower critical oxygen minimum than speckled

Table 1. Means (± SE)[1,2] and ranges for weights (g) of fishes used for critical thermal maxima and critical oxygen minima measurements.

	Weight (g)			
	Thermal maxima		O_2 minima	
Species	Mean	Range	Mean	Range
Fathead minnow	1.82±0.14	1.27-2.72	1.66±0.16	1.07-2.64
Tui chub	1.72±0.16	0.93-2.80	1.73±0.20	0.88-3.02
Shortnose sucker	2.10±0.25	1.16-3.24	1.96±0.22	1.11-3.32
Klamath largescale sucker	2.94*	--*	2.78±0.43*	2.29-3.63
Speckled dace	2.12±0.25	1.53-3.65	2.06±0.11	1.63-2.60
Blue chub	1.62±0.14	0.90-2.16	1.46±0.13	1.19-2.63

[1] 10 replicates for each species except for critical oxygen minima measurements for fathead minnow (9 replicates) and critical thermal maxima (1 individual), and critical oxygen minima (3 replicates) for Klamath largescale sucker.

[2] Weights are not significantly different between species ($P > 0.05$).

* Not enough data for Klamath largescale sucker to warrant statistical comparison with other fishes or a range entry for critical thermal maxima.

dace and blue chub (Table 2). Tui chub and shortnose sucker were similar to both fathead minnow and speckled dace. Although speckled dace had a significantly higher minimum than fathead minnow, they were not significantly different from tui chub and shortnose sucker. Blue chub had the highest minimum. Data on three Klamath largescale sucker suggest they were similar to shortnose sucker and speckled dace.

DISCUSSION

Temperature Tolerance

Our data suggest that fathead minnow and tui chub would be most tolerant, speckled dace and shortnose sucker intermediate, and blue chub least tolerant of high temperatures (Table 2). Possible declines in blue chub populations could be due to increased temperatures. Shortnose sucker were not significantly different from blue chub and have declined in numbers. Speckled dace were also not significantly different from blue chub in their tolerance to high temperatures, but we could not find information on the status of speckled dace populations. Because speckled dace are primarily inhabitants of cool, flowing streams (Moyle 1976), they may find refuge from high temperatures by remaining upstream of warmer reaches of rivers and lakes in the Upper Klamath basin.

The highest temperatures recorded in Upper Klamath Lake did not exceed 30°C (Coleman et al. 1988), and these were recorded only in dense algal scum. Coleman and his coworkers rarely recorded temperatures greater than 25°C in their limnological surveys of Upper Klamath Lake, Agency Lake, and Sprague and Williamson rivers. Even if we consider that critical thermal maxima may overestimate the upper limit of a fishes tolerance range by 2-6°C (Kilgour and McCauley 1986, Becker and Genoway 1979), temperatures rarely reach lethal levels in Upper Klamath Lake for any of the

Table 2. Means (± SE)[1] and ranges for critical thermal maxima and critical oxygen minima of six species of fishes from the Upper Klamath basin.

Species	Thermal maxima (°C) Mean	Range	O_2 minima (torr) Mean	Range
Fathead minnow	33.1±0.2[a]	31.8-33.1	8.4±0.5[a]	6.7-11.3
Tui chub	33.2±0.2[a]	32.3-34.1	9.8±0.7[a,b]	6.7-14.2
Shortnose sucker	32.7±0.1[a,b]	32.1-33.3	11.8±1.0[a,b]	7.5-16.7
Klamath largescale sucker	32.6*	--*	12.7±3.1*	7.9-18.6
Speckled dace	32.4±0.6[a,b]	27.8-33.7	13.4±1.0[b]	8.0-17.9
Blue chub	31.5±0.4[b]	28.3-32.8	18.2±1.4[c]	11.8-25.5

[1]Sample sizes same as for Table 1.

[a,b,c]Means for maxima or minima with similar superscripted letters are not significantly different ($P > 0.05$).

*Not enough data for Klamath largescale sucker to warrant comparison with other fishes or a range entry for critical thermal maxima.

fishes we considered in this study. This does not mean that high temperatures are not affecting the viability of fish populations in the Upper Klamath basin. Earlier life history (egg to juvenile) stages of fish may be more vulnerable to high temperatures, and the ability to reproduce may be more sensitive to environmental stress than any other aspect of a fishes' life history (Gerking 1980). The fact that species ranked in order of increasing tolerance to high temperatures matched their rank in order of declining to increasing populations suggests that high temperatures may play a role in the decline of populations of fishes in the Upper Klamath basin.

The critical thermal maxima of species studied here fall within a 1.7°C range (Table 2) This narrow range suggests that if less tolerant fishes are being adversely affected and environmental conditions continue to decline, all species will soon be affected.

Dissolved Oxygen Tolerance

Critical oxygen minima for the species studied here also fall into a small range, with one exception. Blue chub were less tolerant of low dissolved oxygen than all other species (Table 2), suggesting blue chub would be the first species affected by critically low dissolved oxygen events. Fathead minnow were more tolerant than speckled dace, but were similar to tui chub and shortnose sucker, suggesting these species would be adversely impacted by similarly low levels of dissolved oxygen.

The ability to survive low dissolved oxygen conditions may be important for fish living in Upper Klamath Lake. Dissolved oxygen levels as low as 0.3 mg/l (5 torr) have been measured in Upper Klamath Lake (Scoppettone 1986, Coleman et al. 1988). Vincent (1968) observed that dissolved oxygen levels showed an inverse correlation with tui chub and especially blue chub distributions. Dissolved oxygen levels are lowest near the bottom, exposing bottom dwelling suckers to critically low levels of dissolved oxygen (Buettner and Scoppettone 1990). Scoppettone (1986)

reported that substantial numbers of blue chubs that were trapped live died in the traps and attributed this to the traps confining fish in an area of the lake with low dissolved oxygen. Scoppettone (1986) also reported that both suckers and chubs appeared to be distressed and lethargic during poor water quality events in Upper Klamath Lake.

In Upper Klamath Lake, high temperatures promote algal blooms and these algal blooms result in low dissolved oxygen and high pH conditions (Hazel 1969) such that stressful temperature, dissolved oxygen, and pH conditions occur simultaneously. We have demonstrated low tolerance to high temperature and low dissolved oxygen concentrations in fishes with declining populations in the Upper Klamath basin. Falter and Cech (1991) demonstrated low tolerance to high pH conditions in the endangered shortnose sucker. Unfavorable temperature, dissolved oxygen, and pH conditions probably have synergistic effects on fish survival, such that stressful levels of one variable lowers tolerance of another variable (Wedemeyer, McLeay, and Goodyear 1984). For example, high temperatures reduce the ability of fish to survive low dissolved oxygen events because high temperatures increase metabolic oxygen demand while decreasing hemoglobin-oxygen affinity.

CONCLUSIONS

Our objective was to obtain comparative values for the species we considered. In general, species experiencing population declines were less tolerant of high temperatures and low dissolved oxygen levels than species with relatively stable or increasing populations. This observation supports the hypothesis that increased temperatures and decreased dissolved oxygen levels have contributed to the decline of fishes in the Upper Klamath basin.

Workers in the Upper Klamath basin have observed an increase in fathead minnow populations coincident with a decline in blue chub and have speculated that fathead minnow are replacing blue chub (Jack Williams, Bureau of Land Management, pers. comm.). Our data suggest that blue chub are less well-suited than fathead minnow to changing conditions in the Upper Klamath basin. It is likely that possible declines in blue chub populations are due to degraded environmental conditions, while the increase in fathead minnow populations is due to their recent introduction to the system (Andreason 1975) and their ability to thrive in warmer, less oxygenated waters.

The strength of any conclusion concerning effects of environmental variables on status of fish populations in the Upper Klamath basin is impaired by the lack of published data on these species. In addition, other factors (e.g., environmental contaminants, disease, introduced predators and competitors, dam construction, diversion of water, temporary dewatering of spawning streams, and overfishing) have changed along with changes in temperature and dissolved oxygen levels. Although we can not conclude that increasing temperature and decreasing dissolved oxygen conditions have caused reductions in fish populations, our data suggest that these factors may have played a role in these reductions and/or could prevent the recovery of fish populations.

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ILLEGAL HARVEST OF SPIKE BUCKS DURING A REGULATED MULE DEER HUNT

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The illegal harvest of deer (*Odocoileus* spp.) removes a component of the population that is difficult to assess. This creates an error factor that can be important when developing management plans based on density-dependent harvest rates related to age and sex class. We designed a study to measure the number of spike mule deer illegally killed by licensed hunters and examined how to consider these data in our management plan. We found that spike bucks comprised 3.8% to 11.5% of the total deer kill and their harvest was not correlated to tag type. This percentage represents the minimum number of bucks illegally harvested because hunters did not recognize spikes which were illegal under their respective tags. We recommend that managers regulating land holdings with restricted access consider harvesting spike bucks and manage the total harvest of bucks in accordance with age and sex class.

INTRODUCTION

An accurate estimate of total harvest is important when developing effective management plans for big game. Contemporary plans may incorporate a Linked Sex Harvest Strategy to manage herds in a density-dependent manner where harvest levels of each sex are related to age class and minimum population size (McCullough et al. 1990). These plans are greatly strengthened by knowing the age class of males that are harvested or removed from the herd by hunters. Determining the number of males removed is particularly important in Southern California where mule deer populations are small, non-migratory and in many cases, occupy fragmented habitats. Here, knowing the number of deer killed in each sex and age class is important for developing management plans that avoid over-exploitation.

One of the most difficult components of total harvest to ascertain is illegal kill because of the secretive nature of people that violate laws. Thus, most estimates of illegal kill have large confidence intervals, and often are derived by the indiscriminate use of data collected as part of normal operating procedures, ignoring necessary assumptions required by the statistical analysis used (Cowles et al. 1979). Beattie et al. (1980), in an effort to improve confidence intervals to reliable and meaningful levels, recommended using two or more estimating techniques. Although this may

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give the manager more information, it may be information assembled under bias (Purol and Fournier 1979, Purol 1982). It is important to use a separate technique for measuring illegal kill as a component of total deer harvest.

Studies to estimate illegal kill have focused on several topics. Some studies have measured variability in law enforcement effort affecting either the number of citations written or the ability to catch a violator (McCormick 1968, 1970; Purol 1982). Field studies have used indirect methods to count deer (*Odocoileus* spp.) that were not retrieved by hunters (Schofield 1960, Stapley 1971, Whitlock and Eberhardt 1956). Illegal kill also has been indirectly measured by estimating take either by simulating violation rates or surveying hunters after the season (Vilkitis and Giles 1970, Vilkitis 1971, Wright 1980). These techniques lump mistaken identification in with poaching and crippling loss and do not directly measure the illegal take of game being comprised of three components: deliberate poaching, crippling loss, and mistaken identification.

We designed a system that we believe directly and accurately measured the number of spike mule deer (*O. hemionus*) illegally harvested by licensed hunters as a result of misidentification. Our objective was to determine the number of spike bucks removed from a population and examine this as a component of total harvest. These deer were spike bucks intentionally harvested, yet did not meet the criteria of the hunter's tag. The hunters mistakenly identified these deer as being legal. Previous studies (Schofield 1960, Stapley 1971) indicate that hunters tend to leave these deer in the field.

STUDY AREA AND METHODS

Marine Corps Base Camp Pendleton (MCBCP) comprises 51,800 ha in Southern California. The Base supports a diversity of habitats. It encompasses 27.4 km of coastline, has 2 major estuaries and several lagoons. It includes three major river systems, riparian corridors, marshes and vernal pools; these wetlands comprise 5% of the total area. In addition, terrestrial habitats on MCBCP are composed of 8% oak-savannah, 19% chaparral, 23% coastal sage and scrub sage, 38% grassland, and 7% developed land. Approximately 57% of the total area (29,526 ha) is available for deer hunting. Thirty-six percent of the total area (18,648 ha) is not open to hunting due to unexploded military ordinance, nor is the remaining 7% (3,626 ha) of developed area.

Schofield (1960) found that easily recognizable boundaries to define a study area are a distinct advantage when estimating illegal take. The boundaries of MCBCP, defined and maintained by the US Marine Corps, satisfy this criteria. In addition, the Base is subdivided into 43 training areas defined by maintained roads, ridges and/or drainages.

During our study, deer hunting occurred only on weekends in late August and September due to heavy military training schedules on weekdays. Three tag types were issued: forked horn buck, antlerless, and either-sex. A forked horn buck is defined as "a male deer having a branched antler on either side with the branch in the upper two-thirds of the antler". Antlerless deer are defined as "female deer, fawns of either-sex other than spotted fawns, and male deer with an unbranched antler on one

or both sides which is not more than three inches in length". A hunter with an either-sex tag can harvest either an antlerless deer or a forked horn buck. Spike bucks may not be taken under any tag. (1987-1989 California Hunting Regulations, Part I).

Hunters were regulated at MCBCP to a higher degree than on public hunting lands. All hunters, whether military or civilian, were required to possess a valid California hunting license which mandates either passing a state hunter safety test or possessing a license from a state with an equal requirement. In addition to this initial test, each hunter was required to pass an examination unique to MCBCP before being allowed to hunt on Base. The second examination was to guarantee awareness of regulations concerning MCBCP. The Base examination must be taken each hunting season, regardless of previous passage.

Each hunter was assigned to one of 28 training areas (i.e., hunting units) by lottery. This distributed hunters throughout MCBCP and established hunter densities in proportion to the estimated deer population in each area. Hunter quotas for each area were determined by examining the size, topography, vegetation types, fire history and access, and herd composition counts conducted three months prior to the start of season. Hunter effort was maintained at a nearly constant level for each weekend by creating quotas, offering a short season and dating tags for specific weekends.

A new lottery was conducted every week, assigning a maximum of 140 hunters to all areas. Persons holding valid tags for an upcoming weekend attended the lottery, at which time rules and regulations were reviewed. Special emphasis was placed on which deer could be taken with each tag type. All hunters checked out to and later back in from the field. Hunters were given a pass for their vehicle, which had to be parked in the assigned hunt area. This check out/check in procedure and a known hunter quota alerted law enforcement personnel to the exact hunter activity expected for their patrol areas. The check out/check in procedure occurred at the Game Warden Headquarters, where skinning racks and refrigerator storage tended to centralize hunter activity to and from the field.

Game law enforcement was maintained by a squad of 13-15 Marines trained as game wardens. During deer season, wardens rotated shifts such that 10 wardens were on duty 24 hrs a day. We implemented a policy that strongly encouraged hunters who accidentally and illegally harvested deer to bring the carcass to a game warden or check station. The hunter's deer tag would be taken, along with the carcass, however, the individual would not be cited and retain Base hunting privileges for other game species. Confiscating a hunter's tag would end deer hunting with that tag for the season. This does not prevent a hunter from leaving an illegally killed deer in the field, but is does greatly diminish it, and we believe in our case, nearly to zero.

By encouraging hunters to comply not only with the law, through an amnesty program, but also with our data collection effort, it was possible to measure the minimum number of deer illegally shot as a result of misidentification. This component of illegal kill has not been examined individually in other studies.

RESULTS AND DISCUSSION

Violation rates for buck tags, either-sex, and antlerless tags were determined (Table 1). Over the three year period, three deer were known to be harvested illegally that were not spikes and these were violation errors using buck tags. These violations were: harvest of a doe, loss of a tag, and the shooting of two bucks using the same tag. These 3 violations were included in the total harvest listed in Table 1. Illegally harvested spikes ranged from 5.5% to 11.5% of the total harvest for hunters using buck-only tags and 3.8% to 7.4% for either-sex or antlerless tags. Chi-square tests indicating the probability of a greater value were calculated at 0.93, 0.77, and 0.15, for years 1987, 1988, and 1989, respectively. No significant difference existed between illegal harvest rates of the tag types.

These data were obtained by enforcing the policy of voluntary hunter compliance with harvest regulations. Although not unequivocal, we have reason to believe these were the only harvest violations that occurred during the open deer season. With the amnesty policy, there were no reports of spike bucks shot and left in the field. During previous seasons, without the amnesty policy, hunters would report the locations of spike bucks found shot that had been left in the field.

Table 1. Seasonal harvest of mule deer by tag type showing the percent of harvest accounted for by spike bucks. Harvest includes all deer known to be removed from the population by hunters. Either sex tags were replaced by antlerless tags in 1988 and 1989.

	Year		
Tag Type	1987	1988	1989
Forked horn buck			
Harvest	73	59	61
Spike bucks	4	6	7
Percentage spike bucks	5.5%	10.2%	11.5%
Either sex			
Harvest	88	--	--
Spike bucks	4	--	--
Percentage spike bucks	4.5%	--	--
Antlerless			
Harvest	--	94	80
Spike bucks	--	7	3
Percentage spike bucks	--	7.4%	3.8%
Total harvest			
Harvest	161	153	141
Spike bucks	8	13	10
Percentage spike bucks	5.0%	8.5%	7.1%

We believe that our high warden to hunter to area ratio (approximately 1:14 for 29,526 ha) held violations to a minimum, and violations that occurred were documented and could be attributed to licensed hunters. Due to the security of the Base perimeter and the topographically limited access, poaching pressures from off Base were assumed to be zero during the season. Through a combination of education, assignment of hunters to area by lottery, and a high warden-to-hunter ratio, we were able to incorporate a high degree of control into our study that has been difficult to implement into studies measuring illegal kill (Cowles et al. 1979, Hemstreet 1959). Varying law enforcement efforts result in varying violation rates (Hemstreet 1959, McCormick 1970, Nelson and Verbyla 1984). We believe our study reduced this variance because regulations were consistently applied.

We counted the number of spike bucks mistakenly harvested by hunters. This was doable because hunters were kept informed of the regulations, there was a high probability of a field check by wardens, and law enforcement measures were consistent throughout the study. Under these stringent controls and high visibility of law enforcement, hunters were less likely to violate existing laws. Therefore, spike bucks that were killed were likely those that were misidentified by hunters. We found that the chance of hunter error did not differ with the tag type.

Shooting an illegal deer was not to the hunter's advantage because their hunt using that tag would end. Additionally, the spike buck and hunter were returned to the Game Warden Headquarters for processing where the hunter was interviewed by a game warden and a biologist, and required to prepare the illegal deer for donation. This process happened in the presence of other hunters and no hunter appeared proud of his illegal deer. We believe therefore, that this amnesty program did not encourage people to shoot first and identify the deer later.

Deer killed illegally and crippling loss during the open season may account for up to 90% of harvest total (Welch 1974). Violation rates cited in other studies (Schofield 1960, Stapley 1971, Whitlock and Eberhardt 1956, Vilkitis 1971, Wright 1980) were higher than ours, probably because our study only measured one factor of the overall picture of poaching and wounding losses. We did not conduct post season carcass searches because carcass searches incorporate crippling loss. Our intent was to measure one component of illegal harvest, the percentage of spikes that are mistakenly identified and killed by licensed hunters.

Our results illustrated that about 90% of the deer illegally harvested at MCBCP were spikes, suggesting that hunters are likely to mistake spikes for legal deer regardless of tag type. Wildlife managers that regulate land holdings with restricted access may choose to legalize the harvest of spike bucks and manage the total harvest of bucks in accordance with sex and age class. Spike bucks could then be calculated into the harvest plan. This action should decrease the proportion of illegally killed deer and possibly decrease the total number of bucks harvested from a population. This may ensure a sufficient escapement of males to sustain a healthy herd.

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CONFIRMATION OF THE NORTHERN RANGE OF THE SNUBNOSE SCULPIN (*ORTHONOPIAS TRIACIS*)

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The current published range of the snubnose sculpin (*Orthonopias triacis*) Starks and Mann 1911, extends from San Geronimo Island, Baja California, north to Monterey, and possibly to the Farallon Islands (Miller and Lea 1972, Follett and Ainley 1976). The type specimen was trawled from Cortez Bank off southern California at a depth of 11 to 16 fm (Starks and Mann 1911). The northern limit of the snubnose sculpin's range was established from a second specimen trawled in shallow water near Pacific Grove in Monterey Bay (Gilbert 1914), later from four specimens collected at Point Lobos and Pacific Grove (Hubbs 1926), and from several more specimens collected from the southern end of Monterey Bay at Mussel Point (Point Cabrillo), Pacific Grove, and Pebble Beach (Bolin 1944). Follett and Ainley (1976) recorded eight snubnose sculpins as prey items of pigeon guillemots (*Cepphus columba*) collected in or near their nests on Southeast Farallon Island, but their records are problematical because these bird-transported specimens cannot accurately indicate where the sculpins originated, or even if they were caught around the nesting sites at the Farallones at all.

A specimen collected off the Farallon Islands National Wildlife Refuge (Fig. 1) reconfirms the northern record for the snubnose sculpin and extends the verified range of this species about 160 km farther north than previously reported. While fishing about 0.5 km south of Southeast Farallon Island at lat 37° 42' N, long 123° 00' W on the morning of 16 November 1991, I landed a 18 cm sl female Pacific sanddab (*Citharichthys sordidus*) from a gravel bottom at a depth of about 30 m. Examination of the sanddab's stomach revealed a complete snubnose sculpin in perfect condition. Since the sculpin showed no signs of digestion and its colors were still bright, I believe the sculpin was ingested less than a few hours earlier, and lived in the same general area that the sanddab was caught.

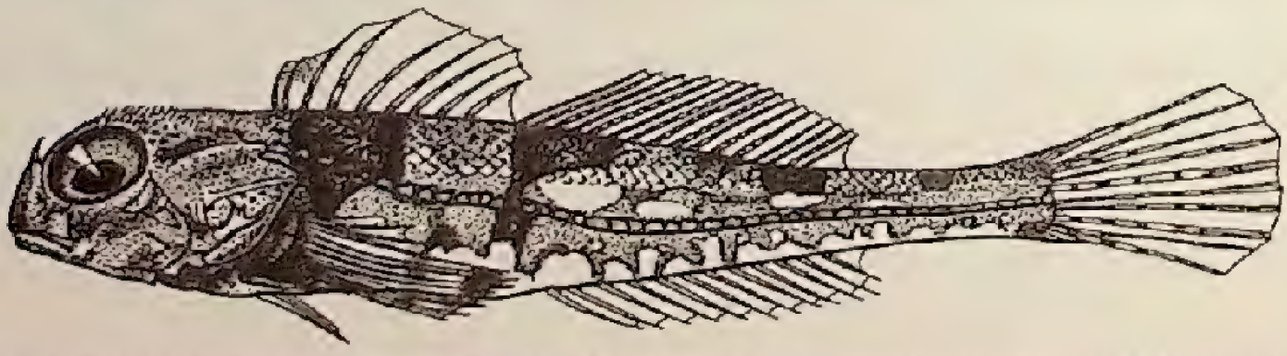

Figure 1. Illustration of the sub-adult snubnose sculpin (*Orthonopias triacis*) (CAS 77379) collected off Southeast Farallon Island (38.2 mm standard length). Drawing by the author.

The snubnose sculpin can be distinguished from other Pacific coast sculpins by the combination of a blunt head with a large orbit; a single thin, sharp preocular spine; dense scales on the top of the head and dorsum; an upper preopercular spine with 2 or more points; and an anteriorly placed anus, usually nearer the pelvic fins than the anal fin (Eschmeyer et al. 1983). This sub-adult specimen (Fig. 1) measured 38.2 mm sl; fin ray counts are as follows: D-IX+16; A-12; Pect. 15; Pelvic I,3. The specimen had four distinct dark saddles on the dorsum. The color (before preservation) was an overall orange with white below, a maroon head, dark brown saddles with a brick-red center in the third saddle, pink between the first and second dorsal saddle, and brown-orange between the second and third saddle. The dorsal and caudal fins had orange barring. The dusky spot at the anterior of the first dorsal fin was indistinct. Based on descriptions and illustrations by Hubbs (1926), Bolin (1944), Miller and Lea (1972), Eschmeyer et al. (1983), and Gotshall (1989), colors and patterns of this species can be quite variable. Although this immature specimen is thinner than adult individuals illustrated by previous authors and lacks the conspicuous anterior dorsal fin spot, it possesses all other morphological characters attributable to *Orthonopias triacis*. This specimen is deposited in the Department of Ichthyology, California Academy of Sciences (CAS 77379).

This offshore record verifies the northernmost known limit of the snubnose sculpin. The species is not restricted just to the continental coast of California, but is also known from several Channel Islands off southern California and from islands off northern Baja (Bolin 1944, Miller and Lea 1972); the specimen from the Southeast Farallon Island reaffirms the coastal and insular distribution of this species in northern California as well.

I thank both Peter Pyle and Denise Hardesty for help in acquiring this specimen during my stay on Southeast Farallon Island, and the United States Fish and Wildlife Service and the Point Reyes Bird Observatory for permission to stay on the Farallon Islands National Wildlife Refuge. I also thank Tomio Iwamoto of the Department of Ichthyology, California Academy of Sciences. This note is also contribution #551 of the Point Reyes Bird Observatory.

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THE CORTEZ GRUNT (*HAEMULON FLAVIGUTTATUM*) RECORDED FROM TWO EMBAYMENTS IN SOUTHERN CALIFORNIA

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The genus *Haemulon* (family Haemulidae) is restricted to the Americas, principally to tropical and subtropical inshore waters (Jordan and Swain 1884). Courtenay (1961) reviewed Atlantic taxa and Hong (1977) treated Pacific species. Eighteen species are considered valid: 13 are Atlantic; four Pacific; and one, *H. steindachneri*, occurs in both oceans. None of the five eastern Pacific *Haemulon* (*H. flaviguttatum*, *maculicauda*, *scudderi*, *sexfasciatum*, and *steindachneri*) have heretofore been reported north of Cedros Island, Baja California, Mexico (ca. lat. 28°05'N).

On 4 May 1987 an unusual fish was collected in Mission Bay, San Diego County, by personnel from Hubbs-Sea World Research Institute. The fish was turned over to the Marine Vertebrates Collection, Scripps Institution of Oceanography, and identified by R. H. Rosenblatt as *Haemulon flaviguttatum* Gill, 1862, the Cortez grunt (Fig. 1); it is catalogued as SIO 88-8. This species has also been referred to as the yellowspotted grunt (Hong 1977). In May 1991 another Cortez grunt was taken by gill net in south San Diego Bay by Mike Irey, a commercial mullet fisherman. This specimen was identified by R. N. Lea and is also deposited at Scripps; SIO 92-82. Counts and measurements for these two specimens are given in Table 1.

The prior known distribution of the Cortez grunt was from Bahia San Juanico (ca. lat. 26°10'N) on the Pacific coast of Baja California and throughout the Gulf of California south to Panama (Thomson et al. 1987).

Several possibilities exist to explain Cortez grunt in Californian waters. A number of tropical fishes were taken off southern California during the mid- and latter part of the 1980's (i.e., post-El Niño condition). Pacific seahorse (Jones et al. 1988), two species of sea chubs of the family Kyphosidae (Brooks 1987), and Cortez angelfish (Lea et al. 1989) are but several examples of fishes whose appearance off southern California was most probably related to physical oceanographic conditions of the 1982-83 El Niño. These expatriates were possibly transported as larvae or juveniles during this period of warm water. However, inadvertent as well as intentional introduction of tropical organisms into San Diego Bay by long-range sportfishing vessels and pleasure craft returning from Mexican waters, including the Sea of Cortez,

Figure 1. Cortez grunt (*Haemulon flaviguttatum*). Specimen from south San Diego Bay, 259.2 mm SL; SIO 92-82.

has long been known. Unfortunately the practice of purposeful introduction has taken place since at least the early 1930's (Clark 1932). Tropical species such as various bait fishes (including grunts), jacks, and other organisms, if released into San Diego Bay could conceivably survive in this warm water environment, especially in areas of thermal enhancement (a power plant that releases heated water is located in south San Diego Bay). Escapement of organisms from large public aquaria as well as release by amateur aquarists must also be considered. The marine aquarium trade has become a major and lucrative enterprise in recent years due to the popularity and availability of tropical marine organisms to the general public.

It is impossible unequivocally to determine the origin of the Cortez grunt recently captured from Mission and San Diego bays. However, it seems most parismonious to us that these fish arrived as expatriates, possibly as larvae or juveniles during a period of warm water, perhaps the El Niño of 1982-83. Otoliths from both specimens were examined. It appears that the Mission Bay grunt was in its fourth year, thus indicating a 1983 birth date. The San Diego Bay specimen shows seven growth rings which would place it in a 1984 year class. Sea surface temperatures off Baja California and southern California were anomalously high for this geographic region in 1984 and were essentially a continuation of the 82-83 El Niño phenomenon. These findings are compatible with a larval dispersal scenario.

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Table 1. Meristic and morphometric data for California specimens- *Haemulon flaviguttatum*[1].

		Location and Specimen	
		Mission Bay SIO 88-8	San Diego Bay SIO 92-82
Counts			
	Dorsal fin	XII, 16	XII, 16
	Anal fin	III, 10	III, 9
	Pectoral fin (l)	17	18
	Gill rakers (l)	11+21=32	10+21=31
Measurements			
	Standard length (mm)	223	259.2
	Total length (mm)	280	321
	Head length	29.6	28.6
	Snout length	8.7	7.9
	Upper jaw length	11.5	11.6
	Interocular distance	8.5	8.4
	Body depth	35.4	31.6
	Predorsal distance	36.9	35.9
	Preanal distance	67.9	69.4
	Caudal peduncle length (dorsal)	17.5	18.9
	Caudal peduncle depth	9.4	9.1

[1]Measurements follow those used by Hong (1977). Morphometric characters, with the exception of standard length and total length, given as percent of standard length.

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OBSERVATIONS OF THE PRICKLY SHARK (*ECHINORHINUS COOKEI*) IN MONTEREY BAY, CALIFORNIA

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The known distribution of the prickly shark (*Echinorhinus cookei*) is throughout the temperate and tropical waters of the Pacific Ocean from central California to Peru, including Hawaii and New Zealand. Specimens have been taken at depths from 10 to 280 m (Garrick 1960, Miller and Lea 1972, Varoujean 1972, Castro 1983, Eschmeyer and Herald 1983, Compagno 1984). *E. cookei* are considered rare, and to our knowledge, there are no previous reports of them observed alive in their natural habitat.

E. cookei were observed in the Monterey Submarine Canyon system near Moss Landing, lat 36°48.7' N, long 121°50.0' W. Sixteen scuba dives were conducted from June 1990 to October 1991 at depths of 15-35 m. The sides of the canyon, composed primarily of soft sediment, begin to fall steeply at approximately 20 m, and it was in the depth range from 20 to 30 m that most of our observations of *E. cookei* were made. The visibility at these depths was generally poor (1-3 m). From one to more than 30 *E. cookei* were observed on 13 of the 16 dives (Table 1).

Once the canyon axis was found, divers descended to 30 m, and swam along the canyon wall at a heading of 270° for approximately 150 m. Distances were estimated with kick cycles. Counts of *E. cookei* were taken to the limit of the visibility (approximately 1 m to 2 m on either side of the divers). At the termination of the first transect, divers ascended to 20 m and swam a second transect on a heading of 90°.

E. cookei that we observed were stationary or swimming slowly, although they could move quickly when alarmed. They were oriented close to the bottom or canyon wall, and were often observed with sediment on their dorsal surface, which is indicative of slow movement (Fig. 1). During one dive, when over 30 *E. cookei* were observed, the sharks appeared to swim haphazardly in many directions. Even under poor visibility, up to four individuals could be seen at one time, indicating their proximity to one another. They generally did not seem disturbed by our presence, and tolerated contact.

Of the more than 90 *E. cookei* encountered, several had distinctive markings. On three, the upper lobe of the caudal fin was stunted (almost missing on one), and two had bumps approximately 1-2 cm in diameter along the posterior trunk and caudal fin area (the only area seen of those sharks). In addition, several individuals were seen

Table 1. Number of prickly sharks (*Echinorhinus cookei*) observed in the Monterey Submarine Canyon, California.

Date	Number of sharks sighted	Visibility (m)	Depth (m)
15 June 1990	10	1.0	32
20 June 1990	30+	2.0	19-24
21 June 1990	12	2.0	32
31 July 1990	3	2.0	26
1 August 1990	0	3.0	20-33
16 August 1990	0	1.5	20-33
13 September 1990	10+	2.0	26
14 September 1990	8	3.0	26
21 April 1991	1	2.0	26
26 May 1991	1	2.5	34
10 June 1991	2	1.0	33
22 June 1991	0	1.5	20-33
26 June 1991	3	1.5	35
7 July 1991	5	1.0	23
7 September 1991	3	1.5	15-24
8 September 1991	5	1.5	28

Figure 1. Photograph of a prickly shark (*Echinorhinus cookei*) in the Monterey Submarine Canyon.

with circular and elongate wounds and scars (approximately 10 cm diameter) along the length of the body. A video record of these observations was taken by the senior author, but we were unable to determine if the same individuals were seen more than once.

Consistent with other authors (Garrick 1960, Tinker 1978), we found the larger *E. cookei* to be thick-bodied, and the girth of one adult (estimated length 4 m) appeared close to 1/4 of its length. Eschmeyer and Herald (1983) suggested that although *E. cookei* is a deep-water species, immature individuals may frequent shallow water. We observed several large females and males over 3 m in length, and large males had well developed claspers. Our observations indicate that adult *E. cookei*, as well as juveniles, are periodically found nearshore, in water less than 35m.

ACKNOWLEDGMENTS

This work would not have been possible without the help of T. Okey who alerted us to the presence and location of the prickly sharks. We thank G. Cailliet and R. Lea for advice, and the Moss Landing Marine Laboratories for providing access to boats and dive facilities. Special thanks to our dive buddies G. Bernardi, J. O'Sullivan, and D. Steller, for sharing in the adventure.

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RECORD OF THE ALLIGATOR GAR (*LEPISOSTEUS SPATULA*) FROM THE SACRAMENTO-SAN JOAQUIN DELTA

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On 17 September 1991 an alligator gar (*Lepisosteus spatula*) (Lacepède), was collected in Clifton Court Forebay (CCF) near Byron, Contra Costa County, California (Fig. 1). Clifton Court Forebay is an 880-hectare water storage reservoir located approximately 130 km upstream from the Golden Gate Bridge at the head of the California Aqueduct (Skinner 1974). Water is diverted into CCF through a gated opening on Old River. Water is pumped from CCF into the California Aqueduct via the Harvey O. Banks Delta Pumping Plant which has a maximum pumping capacity of 6,400 cfs. The fish was captured with a 600-meter long beach seine being used to monitor predator abundance in the forebay. The surface water temperature and approximate salinity during the time of collection was 25°C and 4.5 0/00, respectively. Other species collected in the same beach seine haul were more typical for this area of the Delta and included striped bass (*Morone saxitilis*); white catfish (*Ictalurus catus*) channel catfish (*Ictalurus punctatus*) white sturgeon (*Acipenser transmontanus*)and several species of cyprinids and centrarchids. This is the first

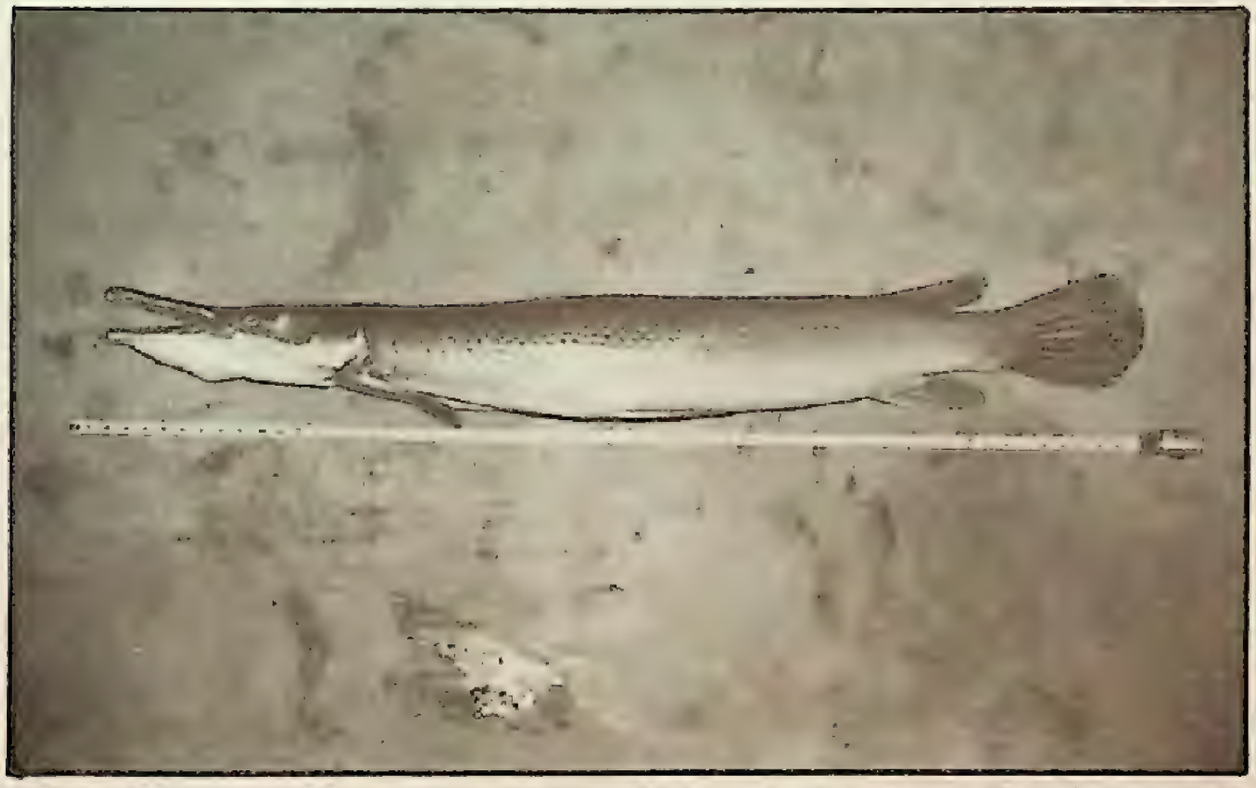

Figure 1. Alligator gar (*Lepisosteus spatula*) 145.5 cm TL taken from Clifton Court Forebay, Byron, California, 17 September 1991. *Photograph by the author.*

reported catch of an alligator gar in public waters of California.

Identification of the specimen was confirmed by P. B. Moyle, University of California, Davis. The specimen was a male, 145.5 cm TL, 59 cm girth and weighed 18.6 kg. Identification of the specimen was based on the following characteristics: blunt snout, large teeth of upper jaw in two rows, and 52 scales before the insertion of the dorsal fin (Trautman 1957, Blair et al. 1957). The alligator gar was judged to be in excellent condition based on the large amounts of fatty deposits. The diverting of unscreened water from the river into CCF provides an abundant year-round food supply for predators. The specimen is being retained in the collection of California Department of Fish and Game, Bay-Delta and Special Water Projects Division, Stockton, California.

The native range of the alligator gar includes the lower reaches of the Ohio and Missouri rivers in the Mississippi River drainage, Econfina River, Florida, and west along the Gulf Coastal Plain to Veracruz, Mexico (Lee et al. 1980, Trautman 1957). P. B. Moyle (pers. comm.) has seen and been informed that gars of various types occasionally occur in local aquarium stores. In the spring of 1991, Warden M.O. Buelna, California Department of Fish and Game law enforcement officer (pers. commun.), seized various types of gar from a local tropical fish store in the San Francisco Bay Area. We believe the most probable source of this specimen is the release of the gar into the Sacramento-San Joaquin Delta or its tributaries by an aquarium enthusiast.

Based on the size, condition and gonadal development of this specimen and the similarity between its native range and the Sacramento-San Joaquin Delta, it is very possible that a viable population would be established if several specimens were to be released into the Delta. The establishment of an alligator gar population would impose another threat to the already declining fishery resources in the Sacramento-San Joaquin Delta.

ACKNOWLEDGMENTS

I would like to thank P. B. Moyle for verifying the identification of the specimen. Special thanks are also extended to J. C. Bull, S. Barrow, T. Owenson, and B. Gorrell for their assistance in the capture of the specimen and D. Pohlman for his assistance in photographing the specimen. This work was performed as part of the Fish Facility Element of the Interagency Ecological Study Program. Funding for the work was provided by the Department of Water Resources and the Department of Fish and Game.

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PREY STORING BEHAVIOR IN THE PANAMIC GREEN MORAY EEL (*GYMNOTHORAX CASTANEUS*)

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The Panamic green moray eel (*Gymnothorax castaneus*) is an opportunistic predator (Hobson 1968). It may swim from cover and actively search for living prey. Usually, it eats each prey animal before searching for another. However, a slightly different feeding behavior was observed during a dive at 4 m in Ensenada de Muertos (23°59' N, 109°49' W), a small bay southeast of La Paz, in Baja California Sur, México, on 15 April 1988 at 14:00 Hr. An individual moray eel was observed swimming almost completely out of its cave towards a school of blue-and-gold snapper (*Lutjanus viridis*). The eel, around 1,000 mm total length, caught one snapper (about 150 mm total length), then returned immediately to its cover, tail first. In the cave, the eel released the fish to bite and swallow a second snapper that was already dead in the cave. A third snapper could be seen lying on the floor of the cave. After swallowing the second fish, the eel remained in the cave with the other two fishes still lying on the bottom, presumably to be eaten later.

This observed behavior, in which the moray eel apparently swam out of its cave three times to catch three different prey before beginning to eat, contrasts with the usual catch-and-swallow sequence. In later dives, a large number of caves of *G. castaneus* were surveyed in this and other areas, but no similar behavior or evidence of it was observed. Feeding experiments, in which several moray eels were fed different types and sizes of prey, did not duplicate the feeding behavior described here. No report of this behavior could be found in the ichthyological literature.

ACKNOWLEDGMENTS

I thank Peter J.P. Whitehead and John Randall for their review and comments on the manuscript.

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NORTHERN RANGE EXTENSION OF THE VERMILION ROCKFISH (*SEBASTES MINIATUS*)

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A vermilion rockfish (*Sebastes miniatus*) was collected by a diver from the Alaska Department of Fish and Game (ADF&G) on 5 August 1990. The specimen, a 325 mm fork length male, was taken in 12 m of water at Zaikof Bay, Montague Island, Prince William Sound (lat. 60°14' N, long. 146°58' W). The specimen was frozen and shipped to the Sitka ADF&G office for identification.

The specimen exhibited features characteristic of a vermilion rockfish, including the occurrence of rough scales on the underside of the mandible (D XIII, 14; A III,7; P 18). Identification was confirmed by using the "key to the rockfishes" in Miller and Lea (1972).

Previously, the northern range reported for vermilion rockfish was Cape Bartolome, Southeast Alaska (Kramer and O'Connell 1986). The Montague Island specimen represents a range extension of about 966 km. The specimen is deposited at the National Marine Fisheries Service Auke Bay Laboratory collection, Auke Bay, Alaska (specimen number AB90-21).

We thank Dan Bosch for collecting the specimen. This is contribution no. PP-55 from the Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau, Alaska.

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CALIFORNIA FISH AND GAME, CALIFORNIA'S LONGEST CONTINUOUSLY PUBLISHED JOURNAL

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While a graduate student at the University of California in the 1980s, I frequently sat in the library flipping through volumes of *California Fish and Game* looking for articles on deer (there have been more than 100 published on deer in California). What I usually ended up doing was getting side-tracked by the wealth of non-technical articles, stories, editorials, color plates, and photographs that comprised the bulk of the journal from its first issue in 1914 until the 1930s. I "wasted" many hours reading stories, life history notes, about wildlife species and their conservation in California and other states. Since the late 1940s, the journal has been a technical journal publishing peer-reviewed articles related to fish and wildlife.

The journal, (early editors called it a "magazine" or "quarterly") has been a State of California publication for 78 continuous and uninterrupted years. The journal has always been produced and printed at the Office of State Printing in Sacramento. The last page typically provided the job number and the number of copies printed, although recently, only the job number has been printed.

Editorship of the journal has rotated among the "fact-finding" programs within the Department of Fish and Game (currently Inland Fisheries, Marine Resources, Bay-Delta, and Wildlife Management). Each program finds a willing participant when its their turn to serve as lead editor. This task comes in addition to the individual's regular duties. One obvious benefit for each of the programs while they have editorship is that the journal tends to emphasize the editors program area (e.g., wildlife) because of the greater familiarity with potential authors, reviewers, and subject matter (i.e., wildlife papers tend to go through the system faster with a wildlife editor than do fisheries papers). Each program assigns "volunteers" to serve as Associate Editors to handle the review process for articles in their area of expertise.

California Fish and Game has had the same cover since its first issue, right? Well, almost. The very first issue in October 1914 (1:1) (Volume 1 had five issues) had a photograph of a waterfall on the cover (I do not know the location of the waterfall). Since then, the traditional cover with the line drawing of a trout (presumably a rainbow), deer, and quail depicting three of the wildlife species of interest in 1914 (original artist unknown). The cover drawing remained unchanged until volume 61(2) when it was cleaned-up and modified, presumably to improve legibility. However, the deer looked like a white-tail with an unlikely antler configuration, and the quail appeared to be a Mearn's with a California quail top-knot.

The phrase "Conservation of wild life through education" is the theme of the journal, and has remained on the cover since the beginning. Issue 38(2) however,

changed the phrase slightly by converting it from drawn text to typestyle and joined the words "wild" and "life" into "wildlife." I recently changed the phrase back to its original two word configuration, but not without comment in the office that I had made a mistake! At its inception, this theme was spawned by controversial issues such as the selling of waterfowl in the markets of California and the closing of Catalina Island waters to net fishing. The first issues of California Fish and Game dealt heavily with the growing concern about utilization and conservation of wildlife (see Volume 25(3):206). The focus was to get the message out to the public about the importance of fish and wildlife conservation. Initially then, the primary target audience was not the scientific or professional reader as it is today.

The cover stock was gray from volume 1(2) to 17(2) and since then has been a variation of green depending on stock available at the printing plant (cover stock is purchased by the plant in bulk orders for a variety of jobs). For its' 75th year in 1989, the journal was printed using a gold cover.

Previous editor Dr. Robert Lea changed the journal from a January-April-July-October format to Winter-Spring-Summer-Fall because he could not guarantee when the issue would come out (it is largely up to the vagaries and priorities of the State Printing Plant). I've recently found that lack of a state budget can also affect publication schedules, I can't guarantee which season an issue will come out!

In the fall of 1990 we implemented some major overhauls related to producing and distributing the journal by converting production to a desktop publishing format on a PC and easily justified from a cost-benefit perspective, the purchase of a computer, printer, and software. Using a scanner, I scanned a recent version of the cover into a graphics "paint" program and modified it to improve the clarity of the line drawings, and most importantly as a California deer ecologist, changed the apparent white-tailed deer with the unlikely antler configuration into a mule deer with more likely antlers. We also modified the quail into a more reasonable (albeit robust) facsimile of the California quail!

The other major change is that the mailing list has been completely re-entered into a PC-based software package (DBASE) to cut costs and hopefully improve efficiency in updating the list. Previously, the mailing list was maintained on a VAX-main frame machine that we could access remotely, was overly cumbersome, and was dependent upon others. These changes have cost little except time. The journal is still considerably off schedule in production and delivery because of the time required to implement these changes, but it is slowly creeping back. The benefit to the subscriber is that the journal is produced more economically and we are able to keep the subscription cost at the same level it has been for several years, which is fantastic given the budgetary problems that have faced the Department of Fish and Game and the state of California.

The Department of Fish and Game regards this publication as an information tool designed primarily to provide its professional biological staff and cooperating scientists with information of specific interest and application to California flora and fauna. Any employee of the Department of Fish and Game may receive the journal free of charge. Additionally, we have a large exchange subscription base with domestic and foreign subscribers and receive many comparable publications for our reference

libraries. Paid subscriptions round out the distribution list. At last look, the journal went to 47 states and 45 countries, as well as most major libraries in California and many other state and federal agencies.

A few articles have been published twice or more. For example, *Bird Life as a Community Asset* by Joseph Grinnell was originally published in 1914. I read it recently and thought it so pertinent to current ecology that I re-ran the article in volume 77(1). Shortly thereafter, I found that editor Richard Croker had also thought it a worthy article when he re-ran it in volume 25(3)! Among the most impressive issues have been the trout, salmon, hawk, and warm-water fish issues which had beautifully done color plates in every copy [e.g., Volumes 3(1), 5(3), 7(3), and 35(4)]. A trout issue was done again in volume 19(2).

During the 1930s, the non-technical aspects of the journal such as editorials, news items, photographs, and observational reports gradually declined. Part of this was due to the establishment of the "*California Conservationist*" in 1936, the official publication of the Department of Natural Resources. This information-packed monthly publication appears to have lasted only until 1941? *Outdoor California*, which apparently was a weekly newsletter beginning in the 1930s, became a monthly publication in 1953. It too, contained similar news items and reports. By the 1940s, all the editorial, news-style information, photographs, and similar information was eliminated from the journal and it became more technical, primarily publishing peer-reviewed articles and notes, with occasional items of interest.

The journal flourished with technical and informative articles from many Department personnel on fish and wildlife during the 1950s-60s. I consider articles published on wildlife during that time to be the most informative, data-rich articles on terrestrial wildlife that the journal has ever published. For example, there were numerous individuals contributing to research efforts on deer and upland game from the late 1940s until the 1960s which spawned many publications in the journal. Efforts from the marine resources and inland fisheries programs however, have likely been the most steady and productive units in the journal's history.

However, an unfortunate trend I have seen in the journal has been a decline in articles published by Department of Fish and Game employees. I think this is symptomatic of a long-term decline in research effort by the Department, increasing responsibilities on the environmental protection front, and the passing of research projects to outside contractors such as the University of California and private contractors. Our current director, Boyd Gibbons, recently expressed his desire to see the Department become more highly respected in the scientific community. Hopefully, this will ultimately translate into a renewed commitment by the Department to strengthen investigation about how California's fish, wildlife, and native plants interact with each other, with their habitats, and with human-induced impacts.

This Department has established quite a prestigious vehicle to carry the message of "Conservation of Wild Life Through Education" for almost 80 years. Take a look back to the past and you'll see that many conservation concerns haven't changed much, we've just made them more complicated.

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INSTRUCTIONS FOR CONTRIBUTORS

EDITORIAL POLICY

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MANUSCRIPTS: Refer to the CBE Style Manual (5th Edition) and a recent issue of *California Fish and Game* for general guidance in preparing manuscripts. Specific guidelines are available from the Editor-in-Chief.

COPY: Use good quality 215 x 280 mm (8.5 x 11 in.) paper. Double-space throughout with 3-cm margins. Do not hyphenate at the right margin, or right-justify text. Authors should submit three good copies of their manuscript, including tables and figures to the Editor-in-Chief. If written on a micro-computer, a 5.25 or 3.5 in. diskette of the manuscript in word processor and ASCII file format will be desired with the final accepted version of the manuscript.

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ABSTRACTS: Every article, except notes, must be introduced by an abstract. Abstracts should be about 1 typed line per typed page of text. In one paragraph describe the problem studied, most important findings, and their implications.

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